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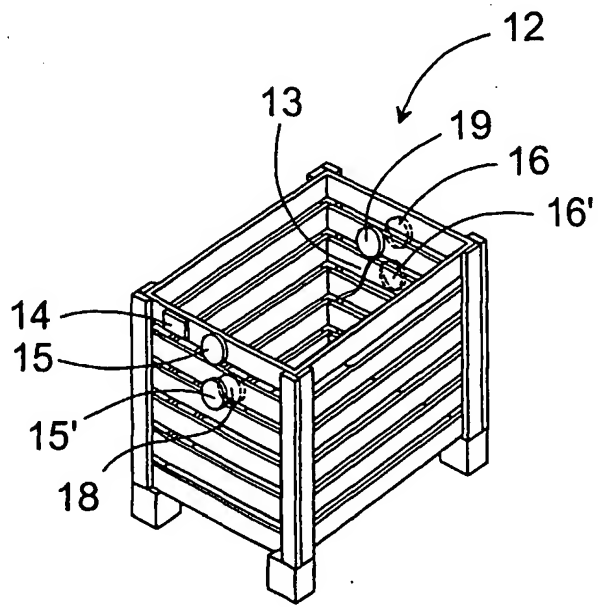
(54) Title: A STORAGE SYSTEM AND A RELATED STORAGE BOX FOR FRESH PRODUCE GROWN OUTDOORS



(57) Abstract: The invention relates to a storage system for fresh produce grown outdoors, which includes: a storage space with controlled temperature and humidity, a large number of storage boxes, means in each storage box, for measuring the properties of the produce, such as its temperature, surface moisture, and/or surface resistance, location information devices are connected to each storage box, for combining the location of the storage box with the measurement information, a central unit and data transmission devices, for collecting the property information.

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A STORAGE SYSTEM AND A RELATED STORAGE BOX FOR FRESH PRODUCE GROWN OUTDOORS

The present invention relates to a storage system for fresh produce grown outdoors, which includes:

- a storage space with controlled temperature and humidity,
- a large number of storage boxes,
- means for measuring the properties of the produce, such as its temperature, surface moisture content, and/or surface resistance,
- a central unit for collecting information of the characteristics.

The invention also relates to a storage box for use in the storage system.

Potatoes, green vegetables, root vegetables, and fruit, as well as other fresh produce, are stored, depending on the produce and situation, for periods of days or even years. The storage is generally intended to match the differences in the timing of the produce's supply and demand to each other, i.e. to store the produce for future requirements, or in some cases (such as bananas) to use the storage to ripen the produce. In all these cases, it is wished to keep the storage conditions as good as possible for the produce, so that it will retain its weight and quality during storage as intended. The storage capacity of commercial fresh produce stores is generally in the order of 300 - 1000 tonnes.

The general conditions of the store (such as the temperature, gaseous composition, and humidity of the air, i.e. the gaseous atmosphere, and the amount of light in the store) are monitored by means of various measuring devices, while the temperature of the produce and the properties of its surface or interior can be monitored by means of sensors, which are situated on top of, or in the middle of the produce. In some known technologies,

only the properties of the air in the storeroom are monitored, in which case the sensors are located only on the walls or ceiling of the storeroom.

If, in stores based on the state of the art, the temperature and, for instance, the surface moisture of the produce are monitored directly from the surface of the produce, the sensors are placed manually in their measurement locations only after the produce being stored have already been put into the store, in which case problems such as the following arise. Because the sensors are connected to the measurement/automation system by means of cables, the store employees must lay the sensor cables over and between the boxes, while very often the sensors cannot be placed in the desired locations, because the boxes of produce have been stacked by fork-lift trucks into a tight-packed stack, which is typically 6-m high, 15-m wide, and 30-m long. Therefore, when using the state of the art, the number and locations of the sensors are always a compromise between the amount of work needed and the desired measurement locations. In the state of the art, the sensors are also often damaged, because the fork-lift truck drivers do not always remember to remove the sensors from the box before removing the box, so that the sensor falls from a great height and is broken, or else the sensor's cable breaks. In all the known technologies, the produce storage boxes are passive, i.e. they really act only as produce storage boxes and are not used to measure and monitor the properties or quality of the produce.

As such, a so-called intelligent foodstuff package is known, which measures and collects data on the conditions of the produce after packing. This does not solve the problem of monitoring the produce from harvesting to packing.

The invention is intended to create an improved storage system for fresh produce grown outdoors and a related storage box, by means of which the problems arising from the state of the art

can be avoided and by means of which a better overall picture of the produce being stored can be obtained. The characteristics of the storage system according to the invention are stated in the accompanying Claim 1 and the characteristics of the storage box used in the system are stated in Claim 9.

The storage box for fresh produce grown outdoors described in this application participates actively in the individuation of the produce it contains and in the monitoring of the properties of the produce. In the following, this new type of storage box is referred to in short by the name 'smartbox'. The smartbox acts not only a storage receptacle and transfer/transportation device for produce, but also as a measuring device of the air surrounding the produce and/or of the temperature and other quality properties of the produce. The smartbox incorporates measurement technology, which measures the temperature of the surrounding air and/or the temperature and other quality properties of the produce it contains and transmits these measurement results to a measurement/automation centre, for examination by the storekeeper and possibly for further processing.

The following describes the typical characteristics of a storage box (smartbox) according to the invention, without, however, in any way restricting the invention to only the characteristics that are depicted here. The smartbox incorporates measurement electronics, which can measure the temperature of the procuce contained in the smartbox, and the surface moisture of potatoes, for example, the moisture and ethene content of the air in the smartbox, and, if necessary, record them for later use. The smartbox also incorporates technology, by means of which the measured data can be transmitted either wirelessly (e.g., by radio), or over a cable to the store's measurement/automation system, for possible later processing and for monitoring carried out by the storekeeper. If the measurement data are transmitted over a cable, it is preferable

to build the necessary cabling as part of the smartbox, so that the cabling apparently 'builds itself', when the smartboxes are stacked next to and on top of each other.

The advantages of the invention according to this patent application, compared to the state of the art are:

An 'intelligent' storage box for produce and an 'intelligent' store

By means of the smartbox technology, it is possible to increase the number of sensors monitoring the state and quality of produce in such a way that they can also be controlled in practice. Because the sensors are part of the produce box, they can be put in the precise locations that are preferable for measurement. The smartbox technology even permits all the produce boxes to be monitored simultaneously. As a medium-sized store can have more than 1000 storage boxes, it is easy to understand that this would be in no way possible in practice using the state of the art. The smartbox's electronics includes individuation of the box, i.e. each box has a 'name and address', and it is possible for the measurement system to know the location of each box in the store (in relation to the other boxes) and the history of the produce contained in it.

Continuous monitoring of produce, from field to package

Produce is often put into storage boxes already in the field, to reduce damage to produce from handling. Many plant diseases infect parts of the plant being stored, precisely when they are lifted from the field, if the lifting conditions favour this. For example, the spore of grey scale in potatoes can grow from the surface of the potato through the skin in about four hours, if the surface of the potato is sufficiently damp immediately after lifting. The smartbox produce box begins to operate immediately after produce has been placed in it. It measures

the properties of the produce already on the field and during transportation to the store and, if necessary, will warn of conditions favouring plant diseases.

Individual monitoring of batches of produce

If all of the produce in the store are stored in smartboxes, the store's automation system will know where a particular produce batch is stored and when the produce is taken from the store the automation system will know the entire history of that precise batch of produce, starting from the field, and how it 'behaved' during storage. If the quality feedback from the sorting line is added to this history, the factors affecting the quality of the product can be analysed for the entire duration of the production chain. Individuation thus makes it possible to monitor the contents of each box individually, from filling in up to the time that the produce is taken to the packing line and packed.

By displaying the product data graphically to the user, the Smartbox technology permits the produce's quality properties (temperature, health, etc.) to be shown as a graphical display, in which the relevant quality property is distributed in the display in the same way as it is distributed in the store on which it is based. Similarly, it is possible to display the origin of the produce (place of growth, seed supplier, or variety of plant, etc.) and its distribution within the store, in relation to the store and to other produce.

In the following, the invention is examined with reference to the accompanying drawings, which show one store system for fresh produce grown outdoors, such as green and root vegetables, and the boxes used in it.

Figure 1 shows a storage box according to the invention.
Figure 2 shows a store according to the invention.

Figure 3 shows a series bus according to the invention.
Figure 4 shows one way of measuring surface resistance.

A storage box 12, according to the invention, a 'smartbox', comprises a traditional box and the electronics installed in it. These electronics include a data unit 14, series bus contacts 15, 15' on one side and second series bus contacts 16, 16' on the opposite side, a temperature sensor 13, as well as surface resistance measurement electrodes 18 and 19 in the inside of the storage box. In addition, the storage box includes the cables between the components, which can be quite easily hidden inside the construction. The data unit 14 includes at least a microprocessor, I/O devices, and a memory, as well as preferably a clock circuit.

The box is generally a cage-like construction open at the top, but other kinds of box equipped with air-flow connections can also be contemplated. The said 'smartbox' can form part of a detachable part of the box, for example, the lid. Either the harvesting machine drops a separate smartbox into each box, while recording the identifier of the box in the memory, or else the box identifier is linked to the other information at the stage when the produce is made ready for sale.

The temperature of the store 10 is controlled in a traditional manner, Figure 2. Once the storage boxes 12 have been stacked next to and on top of each other, ducts are formed under them to openings in the front wall of the store. Cooled air is blown in from these openings, and reaches the interior of the stack through the said ducts.

In addition to the air-conditioning openings in the front wall of the store in Figure 2, there are series-bus contacts 11 and 11', which are connected to the system's central unit.

In the store in Figure 3, eight storage boxes are stacked next to each other, in storage places L1 - L8, between which the series bus is formed. In the store, there a several queues of this kind on top of each other and several parallel to each other. In each queue, there is a series bus between the front wall of the store and the storage boxes, through which the measurement information is transmitted to the central unit. For this, some known data transmission protocol can be used. In the series bus, 'next to each other' can refer to both the vertical and lateral directions.

The series bus can be implemented in many different ways. Instead of a galvanic connection, it is possible to use either a capacitive or inductive connection. Entirely wireless data transmission is one alternative to the series bus.

The data unit preferably includes its own power supply, so that monitoring of the produce can commence already during harvesting, when a produce batch is placed in the box.

At their simplest, the location information devices connected to the storage boxes can comprise of nothing more than a remotely readable identifier in the box, which is recorded according to the stacking order of the boxes, or with the aid of a loading/unloading device equipped with a location information sensor. Alternatively, in connection with the series bus, there can be means for identifying the sequence number of the storage box in the chain, from which its location can be determined.

The measurement of surface resistance takes place with the aid of two sensor electrodes 18 and 19, which are attached to the inner sides of the box. The resistance between them depicts the surface resistance of the produce, Figure 4. In a series bus implemented by means of a galvanic two-terminal connection, the surface resistance can be easily measured between the termi-

nals. According to Figure 4, the surface resistance sensor 18 on the front side is connected to the lower contact 15' of the series bus and on the rear side the sensor 19 is connected to the contact 16, in which case the resistance between the terminals will depict the average situation in the entire queue.

The location information devices forming part of the system can be outside the storage box in such a way that, for example, the transit time delay technique is used to calculate the distances to at least three fixed points, on the basis of a signal sent by the storage box's 'smartbox'.

Claims

1. A storage system for fresh produce grown outdoors, which includes:

- a storage space (10) with controlled temperature and humidity,
- a large number of storage boxes (12),
- means (13, 18, 19) for measuring the properties of the produce, such as its temperature, surface moisture, and/or surface resistance,
- a central unit for collecting information on the properties of the stored produce,

characterized in that

- location information devices are connected to the system, preferably to each storage box, for combining the location of the storage box (12) with the measurement information,
- the system includes data transmission devices (11, 15, 16), for transmitting the measurement/location information of each individual storage box (12) to the central unit.

2. A storage system according to Claim 1, characterized in that at least some of the measurements are arranged to be carried out in each storage box (12).

3. A storage system according to Claim 1 or 2, characterized in that each storage box (12) and the wall or similar of the store includes series-bus devices (11, 15, 16), in such a way that the sequential storage boxes (12) form a series bus for collecting information on the properties of each storage box.

4. A storage system according to Claim 1 or 2, characterized in that the system includes devices for transmitting the information of each storage box (12) wirelessly.

5. A storage system according to any of Claims 1 - 4, characterized in that each storage box includes a power supply, a

microprocessor, and a memory, for recording information as a temporal series beginning from the start of the use of the box during harvesting.

6. A storage system according to Claim 3, characterized in that the series-bus devices include matching electrodes (15, 15', 16, 16') on the opposite walls of the box, for creating a two or multi-terminal galvanic, capacitive, or inductive connection between the sequential storage boxes.

7. A storage system according to any of Claims 1 - 6, characterized in that the interior of the storage box (15) includes opposing sensor electrodes (18, 19) and the system includes means for measuring surface resistance using these sensor electrodes.

8. A storage system according to Claim 7, which uses storage boxes equipped with a galvanic matching electrode connection, characterized in that one matching electrode (18, 19) of each pair in turn is galvanically connected to a sensor electrode in the interior of the box, in which case a value proportional to the surface resistance can be measured from the resistance between the terminals of the entire chain.

9. A storage box for fresh produce grown outdoors, which includes:
a receptacle equipped with air-flow connections and able to be handled by a fork-lift truck, characterized in that the storage box includes
- means for measuring the properties of the produce, such as its temperature, surface moisture, and/or surface resistance,
- a microprocessor and memory, for collecting the property information,
- data transmission devices for transferring the measurement information from the storage box to an external collection unit.

10. A storage box according to Claim 9, characterized in that the storage box (12) includes a location information sensor.

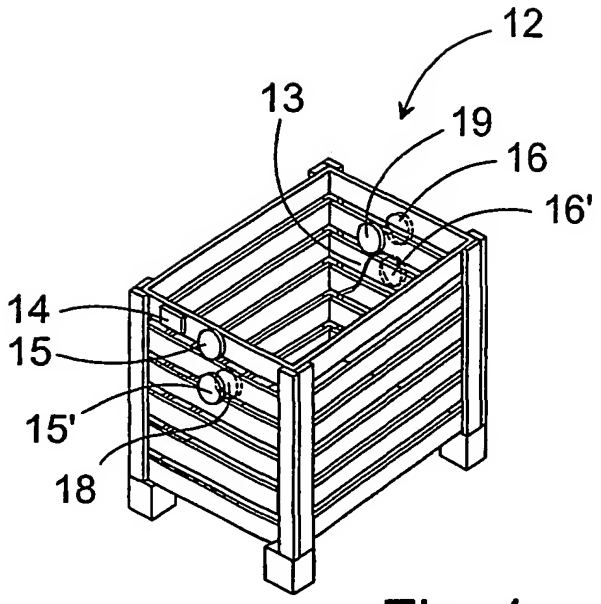

Fig. 1

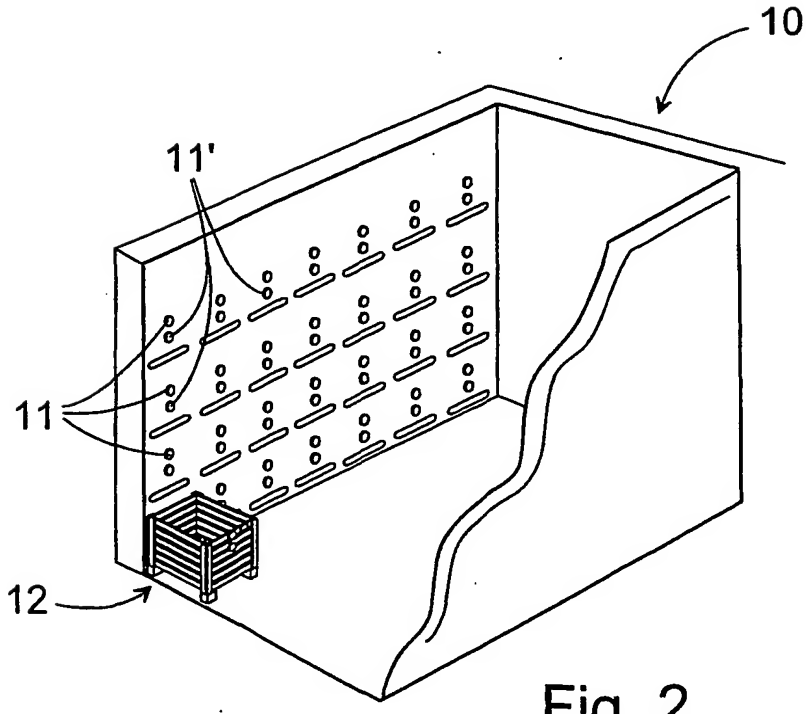

Fig. 2

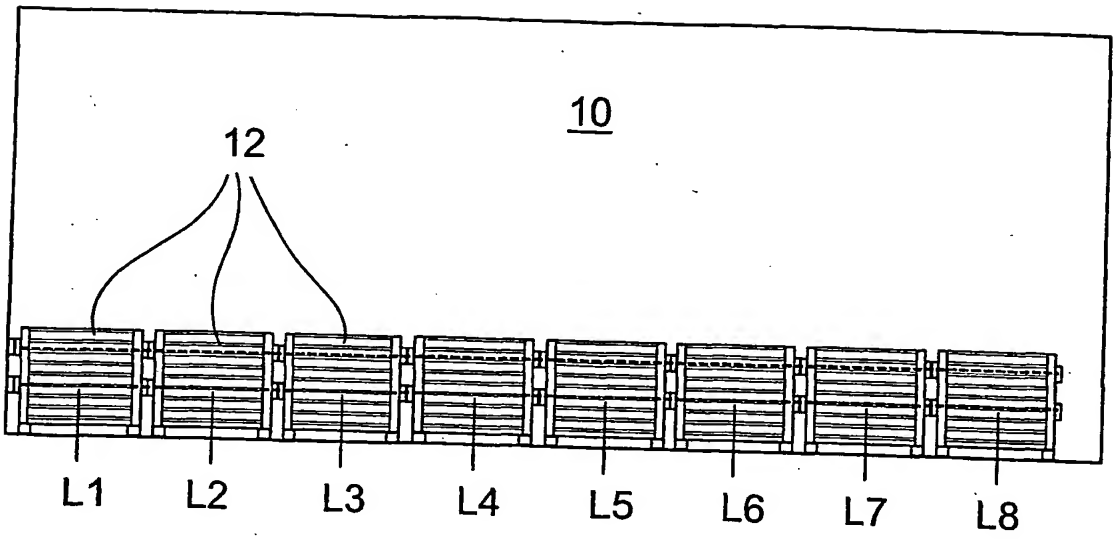
10
12
L1
L2
L3
L4
L5
L6
L7
L8

Fig. 3

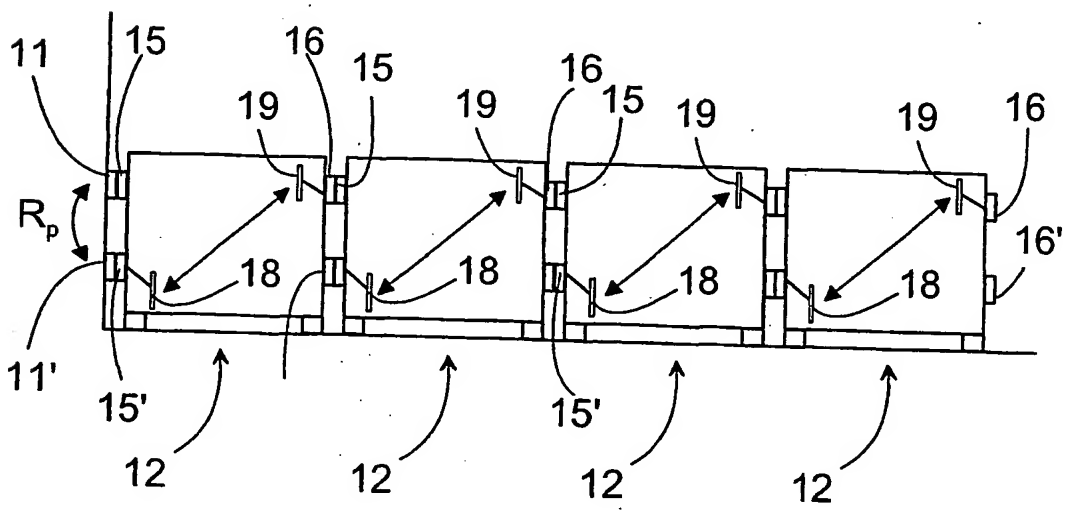
11
15
16
15
19
19
16
15
19
19
16
R_p
16'
18
18
18
18
11'
15'
15'
12
12
12
12

Fig. 4

INTERNATIONAL SEARCH REPORT

International application No.
PCT/FI 01/00728

A. CLASSIFICATION OF SUBJECT MATTER

IPC7: G05B 23/00, G01P 13/00
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC7: B65G, G01P, B65D, A23L, G05B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE,DK,FI,NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	GB 2312054 A (BUSINESS AND TECHNOLOGY LINKS LTD), 15 October 1997 (15.10.97), page 1, line 2 - page 2, line 36; page 9, line 21 - line 25	1-10
Y	Tekesin tutkimusrahoituspäätöksen kohteen n:o 40492/00, 25.4.2000, "'Elekronikkaan ja radiotaajus-teknikkaan perustuvat älypakkaukset" projektin julkinen tiivistelmä	1-10
Y	MEIJER, G.C.M. et al.: "Smart Sensor Systems" http://www.dimes.tudelft.nl/1998/s1/c1/c1-3-smartsensorsystems.html	1-10

[X] Further documents are listed in the continuation of Box C. [X] See patent family annex.

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Date of the actual completion of the international search	Date of mailing of the international search report
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INTERNATIONAL SEARCH REPORT

International application No.
PCT/FI 01/00728

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 5211476 A (COUDROY, JEROME), 18 May 1993 (18.05.93), column 1, line 26 - line 44; column 2, line 34 - line 39	1-10
A	US 5460006 A (TORIMITSU, HIROSHI), 24 October 1995 (24.10.95), column 1, line 25 - column 2, line 7	1-10
P,A	EP 1057752 A1 (EMBACYCLE A/S), 6 December 2000 (06.12.00), page 4, line 13 - line 57	1-10

INTERNATIONAL SEARCH REPORT

Information on patent family members

06/11/01

International application No.
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Patent document cited in search report	Publication date	Patent family member(s)	Publication date
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US 5211476 A	18/05/93	AU 1140192 A	10/09/92
US 5460006 A	24/10/95	NONE	
EP 1057752 A1	06/12/00	AU 4910700 A WO 0075048 A	28/12/00 14/12/00